Technologies of vat dyeing process their application & properties

By: AVM Chemical Industries.

1. About Vat Dyes:

The name Vat was derived from the large wooden vessel from which vat dyes were first applied. Vat dyes provide textile material with the best colorfastness of all the dyes in common use. Vat dyes are an ancient class of dye, based on the original natural dye, indigo, which is now produced synthetically, and its close chemical relative, historic tyrain purple. Cotton and wool, as well as other fibers, can be dyed with vat dyes. Vat dyeing means dyeing in a bucket or vat. It can be done whenever a solid even shade, the same color over the entire garments, is wanted, using almost any dye, including fiber reactive dye, direct dye, acid dye etc. The opposite of vat dyeing is direct dye application, such as, for example. Tie dyeing “vat dyes” are a special class of dyes that work with a special chemistry.

2. Vat dyes synthesis:

Vat dyes are difficult chemicals to make and their structures are complex some of these will be shown the sub heading vat dyes. The different chemical structures affect the solubility of the sodium leuco vat, its stability towards over reduction and over oxidation, its substantively its rate of diffusion into and out of the fibers and the ultimate properties of dyeing.

3. Mechanism:
Solubilised vat dyes are absorbed into cellulosic fiber, wool, silk and nylon from aqueous solutions often containing small amount od sodium Nitrate, followed by hydrolysis in a acidic bath and by oxidation with oxidizing agent as shown in reaction.

\[
\text{NaO}_3\text{S O} \quad \text{Acid Hydrolysis} \quad \text{OH} \\
\text{Solubilized vat dye} \quad \text{O – SO}_3\text{Na} \quad \text{Leuco Acid} \\
\text{Oxidation} \quad \text{OH} \\
\]

**Behavior of Solubilised vat dye in dyeing**

Solubilised vat dyes are very low in affinity for cellulosic fiber as compared with the corresponding leuco salts of vat dyes, so the adding large amount of natural salts to the dyebath.

4. **APPLICATION OF VAT DYES:**

Most vat dyes are sold in insoluble oxidized form. The first operation therefore, consists of reducing to the lecuo compound and dissolving the latter in alkali, a process commonly referred to as vetting. The classical nature vat dyes such as Indigo and Tyrian purple were reduced in fermentation vat.

One of the earlier processes for reducing Indigo, based on the use of chemicals instead of micro – organisms, was with coppear’s as the colloquial name for ferrous sulphate; the ferrous sulphate was then predicated which rapidly reacted with the oxygen with the formation of ferric hydroxide, accompanied by the liberation of hydrogen.

\[
\text{FeSO}_4 + \text{Ca ( OH) }_2 \quad \rightarrow \quad \text{Fe ( OH) }_2 + \text{CaSO}_4 \\
2\text{Fe ( OH) }_2 + 2 \text{ H}_2\text{O} \quad \rightarrow \quad 2\text{Fe ( OH) }_3 + \text{H}_2 \\
\]

Since the Indigo leuco compounds dissolve in mild alkali the excex of calcium hydroxide sufficed for this purpose. the coppear’s method was followed by the Zinc line vat. Based upon the fact that zinc dissolved in lime water formation calcium zincate and hydrogen.

\[
\text{Zn + Ca ( OH) }_2 \quad \rightarrow \quad \text{CaZnO}_2 + \text{H}_2 \\
\]
Nither method was entirely satisfactory because the coppear’s precipitates of either ferric hydroxide or calcium zincates interfered seriously with the dyeing process.

5. **APPLICATION OF INDIGO TO COTTON:**

Since dyeing is carried out at low temperature a good preliminary scour is necessary to make the cotton easily permeable. The dye vessel is filled with soft water and the dissolved oxygen is removed by the addition of 1 oz / 100 gallons of sodium hydrosulphite. The required amount of reduced indigo is added from the stock vat and the goods are immersed in the dye liquor at 20 to 25 ° C (68 to 77 ° F) and agitated for 15 minutes. It is important that a machine or method of handling should be used in which the goods are totally immered to prevent premature oxidation from taking out, the excess which are exposed to the air. At the end of 15 minutes the goods are taken out, the excess liquor is squeezed back, and leuco compound is oxidized by exposure to air. The first dip will only give a pale blue and the sequence of operations is repeated 2, 3, 4 or 5 times until the necessary depth of shade is obtained. Cellulose has not great affinity for the leuco compound of indigo and heavy shades must there fore be built up the successive immersions because an excessive concentration of the dye in the liquor leads to unsatisfactory rubbing fastness. Exhaustion can be improved by the addition of 5 to 40 present of common salt. According to the depth of shade and the liquor ratio. Deep shades are built up by successive in a series of liquor of increasing indigo and thus the first bath might, for example, contain 0.3 g./l of reduced indigo and concentration would increase until, in the sixth, it is 3 to 4 g./l. a counter flow system may be used, the first bath being certified from the second and so on, all addition of reduced indigo being made to the final liquor. When the dyed goods have been exposed to air for large enough for oxidation to be complete, they are second through to remove any insoluble indigo blue deposited on the surface of the fibers.

6. **Properties:**

**Light fastness of Vat dyes:**

Vat dyes are as a class, the most light fast of all dyes. However, not all individual vat dyes are equally resistant to light. The following are lightfastness rating for the unmixed dyes.

<table>
<thead>
<tr>
<th>S/NO</th>
<th>Color name</th>
<th>Color Index name</th>
<th>Lightfastness rating (out of 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VD01 Yellow</td>
<td>Vat yellow 2</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>VD02 Orange</td>
<td>Vat orange 2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>VD03 Red</td>
<td>Vat red 13</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>VD04 Blue</td>
<td>Vat blue 6</td>
<td>7 – 8</td>
</tr>
<tr>
<td>5</td>
<td>VD08 Violet</td>
<td>Vat violet 1</td>
<td>6</td>
</tr>
</tbody>
</table>

A light fastness of 7 is excellent, but a light fastness rating 5 is no better than you’ll find in many other dye classes.

**Wash Fastness:**
The wash fastness rating of vat dyes is about 4 – 5 . The excellent wash fastness of textile material, colored with vat dyes is attributed to the large vat dyes molecule as well as its aqueous insolubility. The large vat dye molecule is trapped within the polymer system of the fiber because of its size and aqueous insolubility and it is absorbed within the fiber system by van der waals forces.

7. References:


